

Plausible Precipitation trends in climate zones of large river basins of Pakistan in Twenty First Century

Ammara Nusrat ^{1*}, Hamza Farooq Gabriel ¹, Umm e Habiba ¹, Habib Ur Rehman², Sajjad Haider ¹, Shakil Ahmad¹, Muhammad Shahid¹, Saad Ahmed Jamal³ and Jahangir Ali⁴

¹ National University of Sciences and Technology, Islamabad, Pakistan;

² University of Engineering and Technology Lahore, Pakistan

³ Paris Lodron University of Salzburg, Austria

⁴ University of Arkansas, Fayetteville, USA

* Correspondence: ammara.phd14nice@student.nust.edu.pk; Tel: +92-346-5001107

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Table S1. Comparative analysis of APHRODITE and ERA5 monthly dataset. Pearson correlation coefficients and Kolmogorov Smirnov Test results (KS Test). (The shaded p-Values are >0.05, depicting the null hypothesis of similar distribution, is not rejected) [1].

Gauging Stations	Time Period	Elevation (m)	Correlation Coefficient			p-Value, KS Test		
			APHRODITE	ERA5	GMFD	APHRODITE	ERA5	GMFD
Astore	1979–2005	2546	0.90	0.65	0.08	0.0001	0.000	0.001
Balakot	1979–2005	1088	0.91	0.77	0.17	0.018	0.069	0.000
GarhiDopatta	1979–2005	819	0.90	0.71	0.25	0.0001	0.336	0.000
Jhelum	1979–2005	234	0.99	0.79	0.31	0.99	0.000	0.238
Kotli	1979–2005	608	0.91	0.83	0.26	0.29	0.568	0.079
Mangla	1996–2005	605	0.96	0.77	0.40	0.74	0.519	0.060
Muzaffarabad	1979–2005	737	0.92	0.71	0.28	0.92	0.248	0.000
Rawalakot	2003–2005	1638	0.95	0.75	0.10	0.11	0.199	0.024
Saifulmaluk	1996–2005	3224	0.37	0.52	0.13	0.0006	0.00	0.069
Sargodha	1979–2005	190	0.78	0.75	0.26	0.0002	0.000	0.002
Sialkot	1979–2005	256	0.91	0.79	0.35	0.29	0.014	0.201

Table S2. Descriptions of the general circulation models (GCMs) used in the study.

Model	Organisation
ACCESS1-0	CSIRO (Commonwealth Scientific and Industrial Research Organisation, Australia) and BOM (Bureau of Meteorology, Australia)
BCC-CSM1-1	
BNU-ESM	Beijing Climate Center, China Meteorological Administration
CanESM2	College of Global Change and Earth System Science, Beijing Normal University
CCSM4	Canadian Centre for Climate Modelling and Analysis
CESM1-BGC	National Center for Atmospheric Research
	National Science Foundation, Department of Energy, National Center for Atmospheric Research

CNRM-CM5	Centre National de Recherches Météorologiques/Centre Européen de Recherche et Formation Avancées en Calcul Scientifique
CSIRO-MK3-6-0	Commonwealth Scientific and Industrial Research Organisation in collaboration with the Queensland Climate Change Centre of Excellence
GFDL-CM3	NOAA's Geophysical Fluid Dynamics Laboratory
GFDL-ESM2G	NOAA's Geophysical Fluid Dynamics Laboratory
GFDL-ESM2M	NOAA's Geophysical Fluid Dynamics Laboratory
INMCM4	Institute for Numerical Mathematics, Moscow, Russia
IPSL-CM5A-LR	Institut Pierre-Simon Laplace
IPSL-CM5A-MR	Institut Pierre-Simon Laplace
MIROC-ESM	Japan Agency for Marine-Earth Science and Technology, Atmosphere and Ocean Research Institute (The University of Tokyo), and National Institute for Environmental Studies
MIROC-ESM- CHEM	Japan Agency for Marine-Earth Science and Technology, Atmosphere and Ocean Research Institute (The University of Tokyo), and National Institute for Environmental Studies
MIROC5	Japan Agency for Marine-Earth Science and Technology, Atmosphere and Ocean Research Institute (The University of Tokyo), and National Institute for Environmental Studies
MPI-ESM-LR	Max Planck Institute for Meteorology (MPI-M)
MPI-ESM-MR	Max Planck Institute for Meteorology (MPI-M)
MRI-CGCM3	Meteorological Research Institute
NorESM1-M	Norwegian Climate Centre

Table S3. Selected GCMs using RCP 4.5 and climate Zones for seasons warm wet cold dry cold wet and warm dry

Zones	Warm Wet	Cold Dry	Cold Wet	Warm Dry
1	BNU-ESM, GFDL-ESM2G, MIROC-ESM, MRI-CGCM3	CSIRO, MPI-ESM-MR, MIROC-ESM, MRI-CGCM3	GFDL-ESM2M, MPI-ESM-MR, MIROC-ESM, CESM, CNRM5, MRI-CGCM3	bcc-csm1, ACCESS, MIROC-ESM-CHEM, MPI-ESM-MR, CSIRO, GFDL-ESM2G, MRI-CGCM3, NorESM1
2	BNU-ESM, ACCESS, MPI-ESM-MR, MPI-ESM-LR, MIROC-ESM	MRI-CGCM3, CCSM4, MIROC-ESM-CHEM, MIROC5, CSIRO	ACCESS, BNU-ESM, CCSM4, CESM, CNRM5, CSIRO, NorESM1	ACCESS, CSIRO, MIROC5, MIROC-ESM-CHEM, CCSM4, CESM
3	MRI-CGCM3, bcc-csm1, MIROC-ESM, MIROC-ESM-CHEM, CSIRO, MPI-ESM-MR, MPI-ESM-LR	ACCESS, CESM, BNU-ESM, CCSM4, IPSL-CM5A-LR	ACCESS, MIROC-ESM-CHEM, MIROC-ESM, CanESM-2, CCSM4, CESM, CNRM5, MPI-ESM-MR, CSIRO, GFDL-ESM2M	MIROC-ESM-CHEM, NorESM1, MPI-ESM-LR, GFDL-ESM2G
4	ACCESS, CCSM4, MIROC-ESM, MRI-CGCM3, BNU-ESM, MIROC5	MPI-ESM-MR, GFDL-ESM2G, MIROC-ESM-CHEM, MRI-CGCM3	GFDL-ESM2M, CSIRO, MIROC-ESM, CESM, CNRM5, MRI-CGCM3	MIROC-ESM-CHEM, ACCESS, BNU-ESM, bcc-csm1, CESM, CNRM5, CSIRO
5	MIROC5, MPI-ESM-LR, MIROC-ESM, BNU-ESM, MRI-CGCM3	inmcm4, CCSM4, CanESM-2, GFDL-ESM2M, CSIRO, MIROC5, MRI-CGCM3	CESM, MPI-ESM-MR, GFDL-ESM2M, MIROC-ESM, bcc-csm1	ACCESS, GFDL-ESM2G, CCSM4, BNU-ESM, CanESM-2
6	NorESM1, ACCESS, MIROC-ESM-CHEM, CSIRO, CCSM4	ACCESS, GFDL-ESM2G, MIROC-ESM, MPI-ESM-MR, BNU-ESM	ACCESS, MPI-ESM-MR, bcc-csm1, BNU-ESM, CCSM4	CNRM5, MIROC-ESM, MIROC-ESM-CHEM, MIROC5, CanESM-2
7	MRI-CGCM3, GFDL-ESM2M, MIROC-ESM-CHEM, MIROC5, BNU-ESM	MIROC-ESM-CHEM, CSIRO, CESM, NorESM1, BNU-ESM, CCSM4	CanESM-2, CSIRO, bcc-csm1, CCSM4, CNRM5, MRI-CGCM3, CESM	MIROC5, CNRM5, MIROC-ESM, MRI-CGCM3
8	BNU-ESM, MIROC-ESM-CHEM, CSIRO, CCSM4, CanESM-2	CESM, CNRM5, MIROC-ESM-CHEM, MRI-CGCM3	CESM, CNRM5, GFDL-ESM2M, MIROC-ESM	CSIRO, NorESM1, MIROC-ESM-CHEM, MRI-CGCM3
9	bcc-csm1, CNRM5, MIROC-ESM-CHEM, CSIRO, inmcm4, MPI-ESM-LR	NorESM1, MIROC-ESM-CHEM, inmcm4, bcc-csm1, BNU-ESM	bcc-csm1, BNU-ESM, CNRM5, CCSM4, CESM, CSIRO	MPI-ESM-MR, ACCESS, bcc-csm1, BNU-ESM, CNRM5, CCSM4, CESM, CSIRO
10	MIROC5, MIROC-ESM, MRI-CGCM3			MIROC5, NorESM1, MIROC-ESM-CHEM, MRI-CGCM3
11	CSIRO, CNRM5, MIROC-ESM, BNU-ESM, CCSM4, CanESM-2			
12	bcc-csm1, inmcm4, MIROC-ESM, BNU-ESM, MRI-CGCM3			

Table S4: Selected GCMs using RCP 8.5 scenarios for seasons Warm Wet, Cold Dry, Cold Wet and Warm Dry

Zones	Warm Wet	Cold Dry	Cold Wet	Warm Dry
1	bcc-csm1, MPI-ESM-MR, ACCESS, MIROC5	MIROC-ESM GFDL-ESM2G, BNU-ESM, MRI-CGCM3, bcc-csm1	CanESM-2, CCSM4, ACCESS, MRI-CGCM3	MRI-CGCM3, CESM, MPI-ESM-LR, GFDL- CM3
2	IPSL-CM5A-MR, MPI-ESM-MR, CanESM-2, MIROC5	ACCESS, BNU-ESM, IPSL-CM5A-LR, CanESM-2	CNRM5, GFDL-ESM2G, ACCESS, MRI-CGCM3	MIROC5, GFDL-ESM2M, MPI-ESM-LR, MRI-CGCM3
3	MRI-CGCM3	MIROC-ESM-CHEM, inmcm4, ACCESS, CanESM-2	NorESM1, bcc-csm1, ACCESS, MRI-CGCM3	MRI-CGCM3, CESM, MPI-ESM-LR, GFDL-CM3
4	MRI-CGCM3, IPSL-CM5A-MR, ACCESS, MIROC5	MIROC5, GFDL-ESM2G, ACCESS, CanESM-2	MIROC-ESM-CHEM, CNRM5, ACCESS, MRI-CGCM3	MRI-CGCM3, BNU-ESM, ACCESS, MIROC5
5	GFDL-ESM2M, inmcm4, CanESM-2, MIROC5	bcc-csm1, CNRM5, ACCESS, BNU-ESM, CanESM-2	MIROC5, GFDL-ESM2M, ACCESS, MRI-CGCM3	CSIRO, CCSM4, ACCESS, MIROC5
6	MRI-CGCM3, MPI-ESM-MR, MPI-ESM-LR, MIROC5	bcc-csm1, MIROC-ESM, ACCESS, CNRM5	MIROC5, GFDL-ESM2M, ACCESS, MRI-CGCM3	CSIRO, IPSL-CM5A-MR, MPI-ESM-LR, MIROC5
7	CanESM-2, CESM, GFDL-CM3, MIROC5	ACCESS, BNU-ESM, bcc-csm1, MIROC-ESM, MPI-ESM-LR	CNRM5, inmcm4, ACCESS, CanESM-2, MIROC5, MRI-CGCM3	GFDL-ESM2M, NorESM1, ACCESS, MRI-CGCM3
8	CNRM5, MIROC-ESM-CHEM, GFDL-ESM2M, MIROC5	MIROC-ESM, GFDL-ESM2M, CNRM5	CNRM5, ACCESS, MIROC5, GFDL-ESM2M	MIROC5, CNRM5, ACCESS, MRI-CGCM3
9	CCSM4, MPI-ESM-MR, GFDL-ESM2M, BNU-ESM, CNRM5	MIROC5, MIROC-ESM, CNRM5	MIROC5, inmcm4, ACCESS, MRI-CGCM3	GFDL-CM3, CanESM-2, ACCESS, MRI-CGCM3
10	CanESM-2, GFDL-ESM2G, GFDL-CM3, MIROC5			MIROC5, CCSM4, ACCESS, MRI-CGCM3
11	GFDL-ESM2M, MIROC-ESM, ACCESS, MIROC5			
12	CanESM-2, CSIRO, ACCESS, MIROC5			

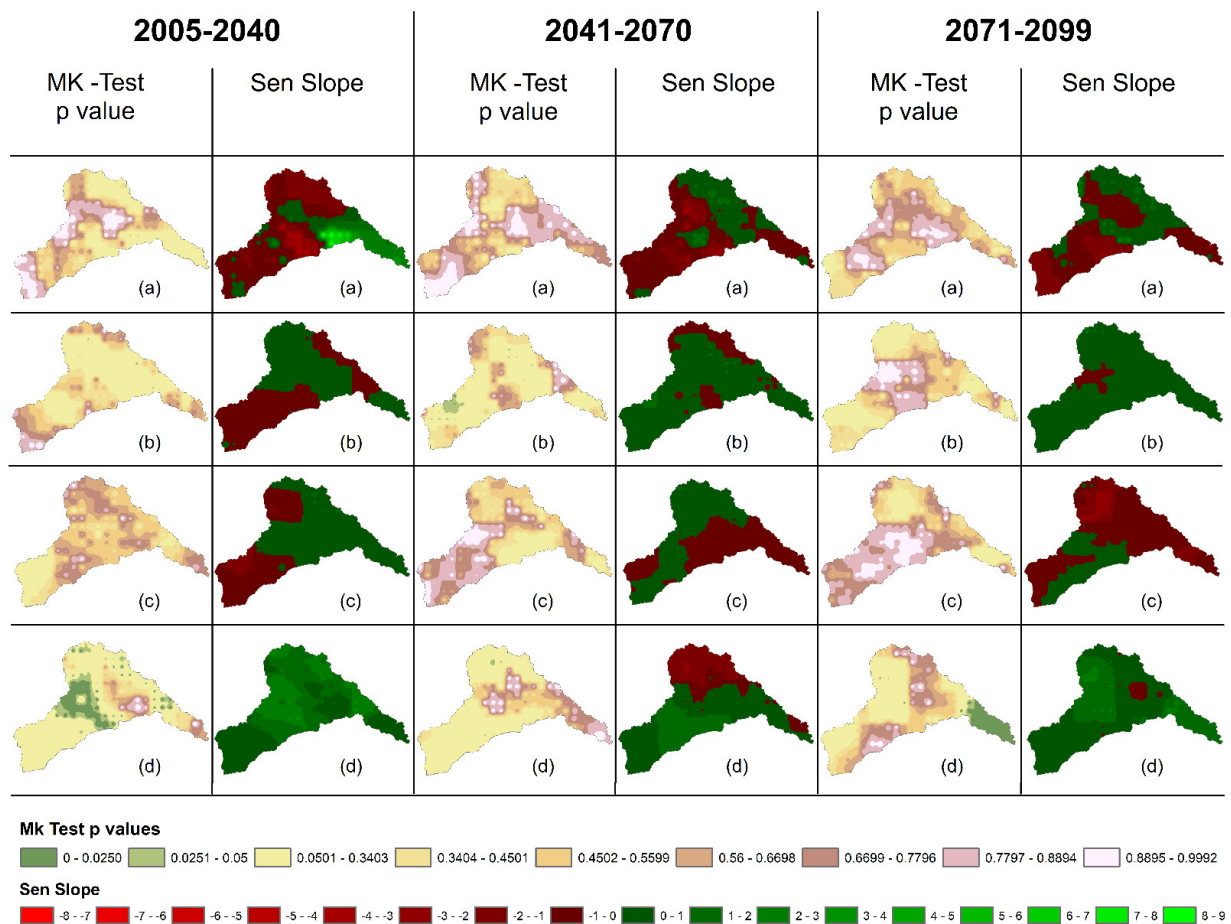


Figure S1. Mann Kendall trend detection and Sen's slope results for MME-Mean using RCP 4.5 (a) Warm Wet (b) Cold Dry (c) Cold Wet (d) Warm Dry

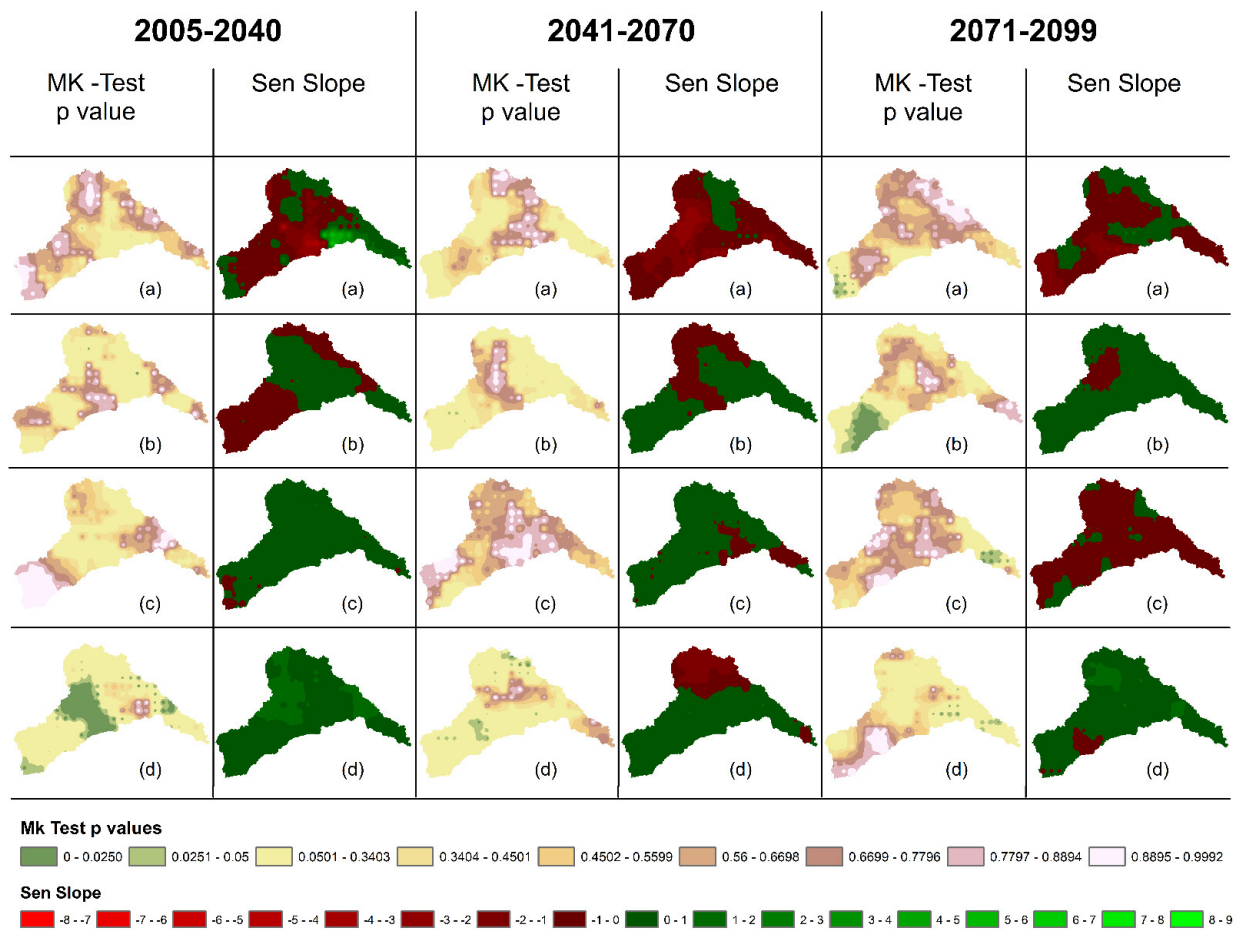


Figure S2. Mann Kendall trend detection and Sen's Slope results for MME-Median using RCP 4.5 (a) Warm Wet (b) Cold Dry (c) Cold Wet (d) Warm Dry

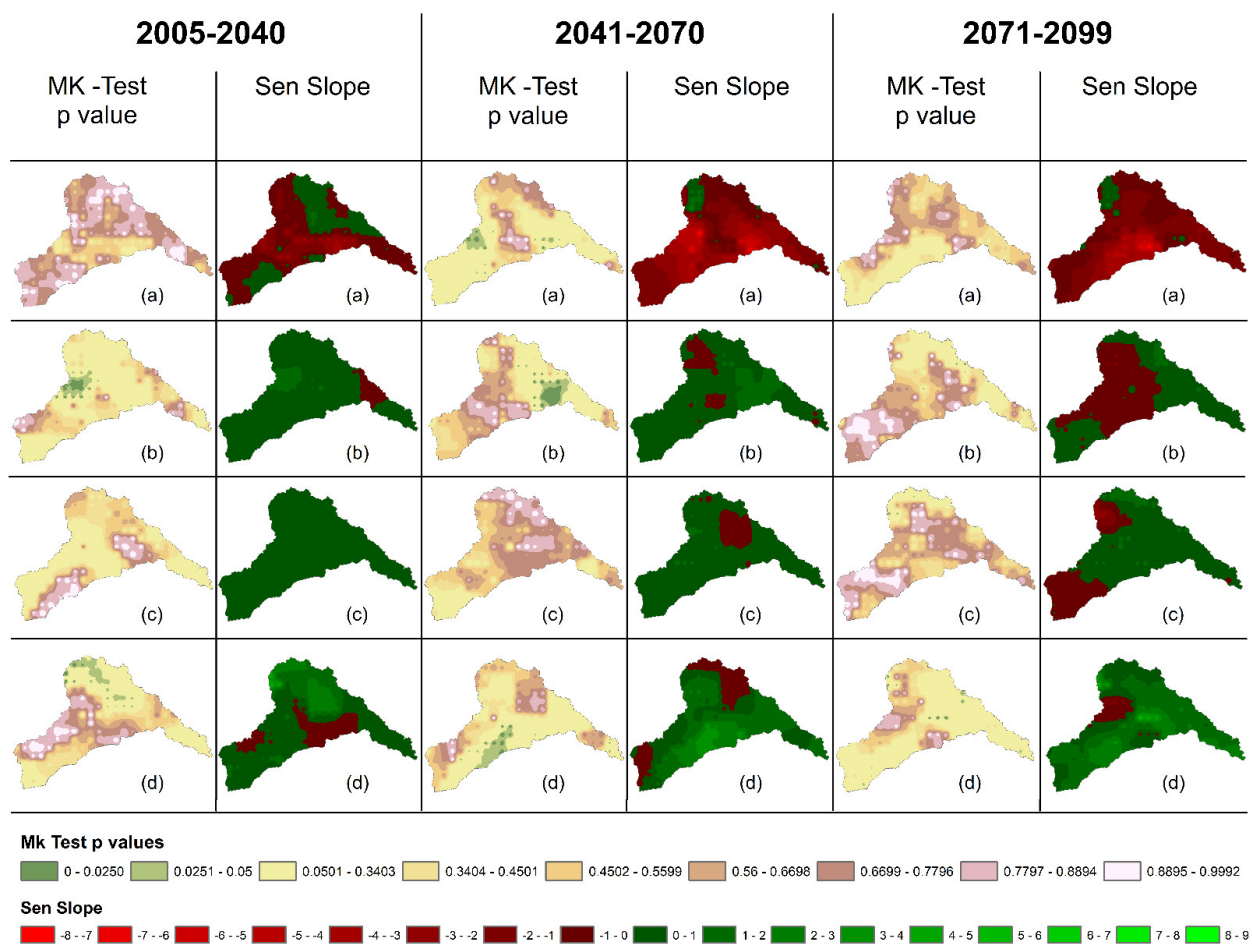


Figure S3. Mann Kendall trend detection and Sen's slope results for MME-Mean using RCP 8.5 (a) Warm Wet (b) Cold Dry (c) Cold Wet (d) Warm Dry

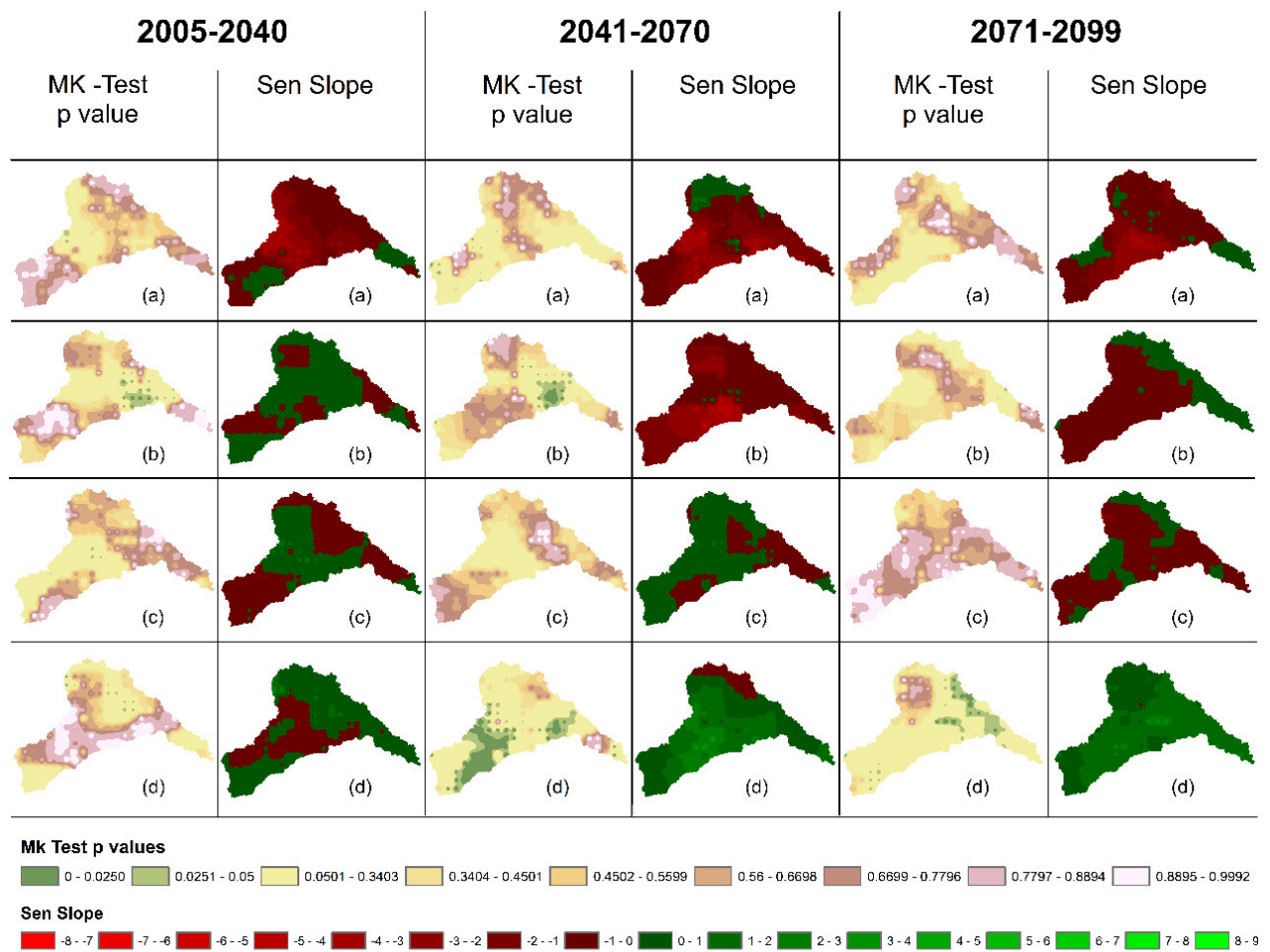


Figure S4. Mann Kendall trend detection and Sen's slope results for MME-Median using RCP 8.5 (a) Warm Wet (b) Cold Dry (c) Cold Wet (d) Warm Dry

1. Nusrat, A.; Gabriel, H.F.; Haider, S.; Ahmad, S.; Shahid, M.; Ahmed Jamal, S. Application of Machine Learning Techniques to Delineate Homogeneous Climate Zones in River Basins of Pakistan for Hydro-Climatic Change Impact Studies. *Applied Sciences* **2020**, *10*, 6878.